Technical Attachment

Impact of Targeted Observations on NCEP Model Forecasts

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(Ed. note: readers are encouraged to refer to the on-line version of this paper in order to gain the most from the color illustrations. We indicate those figures with underlining in this printed version, but have omitted them for brevity. The on-line version can be found at: http://wwwt.emc.ncep.noaa.gov/gmb/targobs/target/wsr2000/example0209/obsimpact.html.)

Extensive studies over the past few years have demonstrated that taking what are called "adaptive observations," or targeted observations, over the northeast Pacific to gather additional upper air information can result in significantly improved downstream forecasts over the continental U.S., several days subsequent to the observations. In addition, it is possible to assess *where* those targeted observations should be taken in order to maximize the potential benefit. Following is an example which pertains to the possible development of a low pressure system over the northeastern U.S., illustrating how ensemble model forecasts are important in what has become an operational wintertime program for targeted observations.

The 5-day ensemble mean MSLP (mean sea level pressure) forecast verifying around 0000 UTC on February 12, 2000, indicated an elongated low pressure system extending northeast, with maximum normalized spread values up to 2.5 times larger than their usual values at this lead time near the southern tip of Lake Michigan (orange colors). The ensemble mean forecast over the same area called for 1016 mb pressure level. The MRF control forecast predicted 996 mb, and the ensemble spread around the ensemble mean in the area was around 10 mb. The verifying analysis showed a value around 1024 mb. The large ensemble spread of 10 mb correctly indicated that much lower or higher values than the 1016 mb ensemble mean were plausible. Fast growing atmospheric instabilities, given the current hemispheric observing network, did not allow for more accurate predictions for this particular area at 5-day lead time.

The 5-day forecast initialized at 0000 UTC on February 7 indicated around a 50% probability of more than a half inch of precipitation would be associated with this storm, and because of the large uncertainty associated with the above forecast feature, HPC initiated the process to request adaptive observations be taken in order to reduce the uncertainty (details of the request are shown below). Due to the long advance notice required by Air Traffic Control before dropsondes can be released from any aircraft, planning for a flight on February 9th had to be prepared on the 7th. Given the verification times and locations in the HPC request, sensitivity calculations were carried out to determine the area from where data taken around 0000 UTC on February 9 could most influence model forecasts for the selected feature. The sensitivity chart indicated that on this day a large area extending from 175 to 120W, and from 35 to 50N was highly relevant for downstream forecasts verifying around 40N, 87W, three days later. The 2-day forecast initialized at 0000 UTC on

February 7 indicated the two most sensitive areas were associated with a very deep low pressure system west of the Dateline, and a small, shallow low pressure wave around 140W. Of the two maxima that were within reach from Anchorage (where the NOAA Gulfstream-IV aircraft was based), the eastern one (around 37N, 140W) was estimated to be more important.

The sensitivity technique also provides an estimate of how the data can be expected to influence the forecasts. The estimated data impact chart should be evaluated only in a qualitative way, but it indicated the impact of the data would travel slowly to the east, reaching the U.S. west coast within 36 hours, and a larger impact could be expected over the eastern half of the continent with around 72-84 hours lead time. We can compare the predicted data impact chart to the actual impact of the data, determined as the difference between two independently run analysis/forecast cycles. The actual signal evolved in a way similar to what was predicted, and the data had a large impact in the preselected verification areas/times. Much of the impact was positive. The red contours on the comparative verification chart indicate that forecast errors were reduced due to the use of the adaptive data, while the blue contours over smaller areas indicate an increase in forecast errors. Overall, the 72-hour forecast initialized using all operationally available data - including the targeted observations - provided much improved guidance compared to the 120-hour forecast, indicating two low pressure systems would follow each other along similar paths, and that around 0000 UTC on February 12 the verification area around 40N, 87W would be dominated by a high pressure system between the two lows.

Following is the HPC request to initiate targeted observations for the above case.

Subject: Reconnaissance Areas from 0000 UTC Feb 7 2000
Date: Mon, 07 Feb 2000 09:08:23 -0500
From: Stephen Flood <Stephen.Flood@noaa.gov>
To: zoltan.toth@noaa.gov

Here are today's key areas. They may look a bit redundant, but you can vary by as much as a day a flight with the same weather system to maximize logistics.

Priority	VT	Area	Remarks
High	021112	40N/95W	Central US system highly uncertain in medium range models.
High	021212	45N/75W	Same system as above...24 hrs later.
Medium	021300	40N/120W	Broad area of spread NOAM W coast.
Medium	021300	50N/135W	Second max within same broad area.

Addendum:
021200 42N 125W west coast precip event (low)
021400 42N 97W possible second low pressure wave affecting eastern US (low)

In summary, based on results from several years' field programs (NORPEX-98, WSR99 and WSR00), the following conclusions have been drawn:

- Of the 63 targeted events, 70% of the cases showed a clear improvement in the quality of 24-96 hour lead time forecasts, measured in terms of error reduction in surface pressure, tropospheric wind, and precipitation forecasts. Only13% of all cases showed a degradation, while in the rest of the cases the adaptive data had neutral impact.

- Within the verification regions that were preselected based upon large expected societal impact/threat (spanning the continental U.S. and Alaska), the average error reduction is on the order of 10-25%. This can be compared to the 10% error reduction due to enhancements in data quality and quantity in the global observing network over the extratropical Northern Hemisphere over the past 25 yrs (including new satellites, etc). When comparing the numbers above one should keep in mind that the targeted data has a relatively large impact over a region only (though the regions are selected based on their importance), while overall improvements to the global observing system enhance the forecasts everywhere.

- The 10-25% rms error reduction translates to a gain in forecast accuracy equivalent to using a forecast (based on non-adaptive observations only) that is issued 12-24 hours later.